U.S. Department
of Transportation
Federal Aviation Administration

Advisory Circular

Subject: SMALL AIRPLANE CERTIFICATION COMPLIANCE PROGRAM | **Date:** | **Initiated By: ACE-100** | **AC No: AC 23-15A** | **Change:**

1. PURPOSE. This advisory circular (AC) provides a compilation of historically acceptable means of compliance to specifically selected sections of 14 CFR part 23 that have become burdensome for small, simple, low performance airplanes (see Applicability section below) to show compliance. However, applicability of these means of compliance remains the responsibility of the certification manager for each specific project. Utilization of these means of compliance does not affect the applicability of any other certification requirements that fall outside the scope of this AC. This material is neither mandatory nor regulatory in nature and does not constitute a regulation.

   Applicability:

   Small, Simple, Low Performance Airplanes –

   The subject of this Advisory Circular. The terms "small airplane", "simple airplanes", or "small low performance airplanes", used throughout this AC, are synonymous with "Small, Simple, and Low Performance Airplanes". This AC is applicable to airplanes with the following characteristics:

   - Single reciprocating engine (Part of CLASS 1 definition in AC 23.1309-1C)
   - Less than 6,000 pounds (part of CLASS 1 definition in AC 23.1309-1C)
   - 4 Seats or less including pilot and co-pilot seats
   - Unpressurized fuselage
   - Normal category maneuvers only (see part 23, §§ 23.3(a)(1) through 23.3(a)(3) for definition of "normal category maneuvers")
   - Conventional materials and techniques – i.e. wood, aluminum monocoque/semi-monocoque or tubular steel design, and no composite (i.e. graphite/epoxy), primary structure
   - Primary structure (as used above) is that structure which contributes significantly to resisting or transmitting flight or ground internal loads, or may lead to an unsafe condition if failed. Some examples (not an exhaustive list) of primary structures are:
     (1) Fuselage frames, stringers and skins
     (2) Wing, horizontal stabilizer and vertical stabilizer spars, ribs, and skins

  (3) Bulkheads
  (4) Intercostals
  (5) Door and window edge frames, sills, or posts
  There may be instances where a portion of structure is not clearly "primary structure" and thus will require the judgment of the Aircraft Certification Office (ACO) engineer.

- No unique, un-orthodox, or complex design features in this context:
  (1) A "unique" design feature is something that the current regulations may not adequately address.
  (2) An "un-orthodox" design feature is something that is not typically seen in an airplane of this type, for example, and canard or forward swept wing.
  (3) A "complex" *design feature* is not the same as a complex *airplane* (defined below). Precisely what constitutes a complex design feature is a determination that can only be made based on the judgment of the ACO engineer. As a rule of thumb, if a design feature is difficult (from the perspective of an engineer experienced in their field) to understand, analyze, reliably predict the behavior of, or prone to failures (due to complexity), that may create an unsafe condition, then it may be deemed as "complex"
- Engine is 200 Horsepower (HP) or less. NOTE: Airplanes with engines over 200 HP are "high-performance" under Title 14 Code of Federal Regulations, part 61, § 61.31 (f).
- The airplane may have no more than 2 of the following 3 items. NOTE: An airplane having all 3 of the following items are "complex" under Title 14 Code of Federal Regulations, part 61, § 61.31(e).
  (1) Retractable Landing Gear
  (2) Flaps
  (3) Controllable pitch propeller
- No wing, leading edge, high lift devices.
- For airplanes equipped with trailing edge wing flaps, the design should be a simple, standard design, such as "plain", "split", "fowler", or "single slotted".

This AC applies only to these types of aircraft. However, certification requirements must always be coordinated with the local ACO. The ACO will make the determination of the suitability of this AC, based on a review of the aircraft design. It is always within the applicants right to propose the use of this AC to show compliance, and to negotiate this with the ACO.

2. CANCELLATION. AC 23-15, Small Airplane Certification Compliance Program, dated January 2, 1997, is cancelled.

3. RELATED REGULATIONS AND DOCUMENTS.

a. Regulations: Title 14, Code of Federal Regulations (CFR), Part 23:

Section 23.45	Performance: General.
Section 23.51	Takeoff speeds.
Section 23.65	Climb: All engines operating.
Section 23.75	Landing distance.
Section 23.77	Balked landing.
Section 23.145	Longitudinal control.
Section 23.161	Trim.

Section 23.175	Demonstration of static longitudinal stability.
Section 23.201	Wings level stall.
Section 23.203	Turning flight and accelerated turning stalls.
Section 23.207	Stall warning.
Section 23.221	Spinning.
	Section 23.562Emergency landing dynamic conditions.
Section 23.605	Fabrication methods.
Section 23.629	Flutter.
Section 23.641	Proof of strength..
Section 23.677	Trim systems.
Section 23.723	Shock absorption tests.
Section 23.725	Limit drop tests.
Section 23.726	Ground load dynamic tests.
Section 23.727	Reserve energy absorption drop test.
Section 23.735	Brakes.
Section 23.853	Passenger and crew compartment interiors.
Section 23.865	Fire protection of flight controls, engine mounts, and other flight structure.
Section 23.867	Electrical bonding and protection against lightening and static electricity.
Section 23.954	Fuel system lightning protection.
Section 23.965	Fuel tank tests.
Section 23.1301	Function and installation.
Section 23.1309	Equipment, systems, and installations.
Section 23.1311	Electronic display instrument systems.
Section 23.1337	Powerplant instruments installation.
Section 23.1431	Electronic equipment.
Section 23.1581	Airplane Flight Manual and Approved Manual Material-General.
Section 23.1585	Operating procedures.
Section 23.1587	Performance information.

b. Advisory Circulars.

AC 20-53A	Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition Due to Lightning
AC 20-115B	Radio Technical Commission for Aeronautics (RTCA), Inc., Document RTCA/DO-178B
AC 20-121A	Airworthiness Approval of Loran-C Navigation Systems for use in the U.S. National & Airspace System (NAS) and Alaska
AC 20-130A	Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors

AC 20-135	Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards and Criteria
AC 20-136	Protection of Aircraft Electrical/Electronic Systems against the Indirect Effects of Lightning
AC 21-22	Injury Criteria for Human Exposure to Impact
AC 21-40	Application Guide for Obtaining a Supplemental Type Certificate
AC 23-8A	Flight Test Guide for Certification of Part 23 Airplanes
AC 23-11	Type Certification of Very Light Airplanes with Powerplants and Propellers Certified to Part 23 and 35of the Federal Aviation Regulations
AC 23-16	Powerplant Guide for Certification of Part 23 Airplanes
AC 23-17A	Systems and Equipment Guide for Certification of Part 23 Airplanes
AC 23.562-1	Dynamic Testing of Part 23 Airplane Seat/Restraint Systems and Occupant Protection
AC 23.629-1A	Means of Compliance with Section 23.629, “Flutter”
AC 23.1309-1C	Equipment, Systems, and Installations in Part 23 Airplanes
AC 23.1311-1A	Installation of Electronic Displays in Part 23 Airplanes
Airframe and Aircraft Equipment Engineering Report (AEER) No. 45	Simplified Flutter Prevention Criteria for Personal Type
FAA Technical Report DOT/FAA/CT-89/22	Aircraft Lightning Protection Handbook

The AC's listed above (with the exception of AEER No. 45) can be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785.

AC's 21-40, 23-17A, and 23-8A are for purchase and can be obtained from the Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954, or from any of the Government Printing Office bookstores located in major cities throughout the United States.

All of the above AC's (with the exception of AEER No. 45 and the technical report) are also available free of charge in electronic format from the FAA's Aircraft Certification Service web page, located at the following Internet address: http://www.faa.gov/certification/aircraft/

AEER No. 45 is available from: Manager, Standards Office (ACE-110), Federal Aviation Administration – Small Airplane Directorate, 901 Locust, Room 301, Kansas City, MO 64106 or on the Internet at: http://www.faa.gov/certification/aircraft/aceAEER45-Flutter.pdf

Technical Report DOT/FAA/CT-89/22 is available by order through the National Technical Information Service, Springfield,Virginia 22161

c. Industry Documents. The RTCA documents listed below are available from the RTCA, Inc., suite 805, 1828 L Street NW, Washington, DC 20036-4001:

RTCA/DO-160D	Environmental Conditions and Test Procedures for Airborne Equipment
RTCA/DO-178B	Software Consideration in Airborne Systems and Equipment Certification

4. BACKGROUND. Some industry and aviation organizations expressed concern that the typical means of compliance for some regulations might be more demanding than justified. As a consequence, industry, aviation groups, and the Federal Aviation Administration (FAA) formed a team to study this issue. Historical files, Designated Engineering Representatives (DER's), ACO's, and industry were used to determine target regulations and provide known means of compliance. This AC is a compilation of the study results, listing the regulations and attendant means of compliance that offer an improvement in certification efficiency. The listed means of compliance have been found acceptable and historically successful, but they are not the only methods, which can be used to show compliance. In some cases, highly sophisticated airplanes may require more accurate or substantial solutions.

5. ACCEPTABLE METHOD OF COMPLIANCE. The selected methods of compliance are organized by affected sections of part 23.

a. Performance - General.

(1) Regulations Reference. Sections 23.45 and 23.1587.

(2) Discussion. Section 23.45(e), requires that performance data for compliance demonstration be based on engine power at 80 percent humidity. The rule also addresses approved power or thrust reduced by maximum installation losses and accessory power extraction. This advisory material is provided for application to small airplanes to address these issues as follows:

(a) Humidity Adjustment. Subsections 23.45(e) requires that performance data for flight requirements compliance demonstration (and for performance information included in the Airplane Flight Manual (AFM) under § 23.1587) be based on engine power at 80 percent relative humidity. Based on AC 23-8A, appendix 1, paragraph 2.d.(3), no humidity correction is required for small airplanes. This paragraph states that, "Experience has shown that conditions such as 80 percent relative humidity on a standard day at sea level has a very small effect on engine power...." "Standard" atmospheric conditions referenced in § 23.45 means United States Standard Atmosphere. See AC 23-8A, paragraph 16a(2).

(b) Engine Power Losses. The rule contains language regarding "approved power or thrust" reduced by maximum installation losses and accessory power extraction. For small airplanes, the prime losses pertaining here are those associated with induction and exhaust systems; the typical accessories that extract power are the electrical and vacuum systems. Since all testing is accomplished with the intake and exhaust systems installed on the airplane, no further corrections for losses are applicable. The typical electrical power source, an alternator, on small airplanes (12 volts at a maximum capacity of 60 amps) will consume under one horsepower maximum. Testing is normally done with the electrical system on, thereby reducing any potential power correction for the alternator's power extraction to much less than one horsepower. Vacuum pumps extract approximately one-half horsepower. They typically run all the time and would be expected to be operating during performance testing and, therefore, no correction for vacuum power extraction is warranted. Also, because of the difficulties associated with power determination when using fixed pitch propellers, the best approach is to use full throttle setting for takeoff and climb performance testing.

(c) Test Instrumentation. For measurement of altitude, airspeed, and temperature, a measurement device, such as that developed for the Comparative Aircraft Flight Efficiency, Inc. (CAFE) Triaviathon, will be an acceptable means of generating required data for measuring rate of climb, climb gradient, glide gradient, airspeed, balked landing criteria, etc. (CAFE Foundation, 4370 Raymonde Way, Santa Rosa, CA 95404)

This device records indicated airspeed, true airspeed, mean sea level (MSL) altitude, and outside air temperature once per second into a computer memory. It then performs all corrections and calibrations necessary. Video cameras may also be used to record instrument readings and pilot actions to show compliance with flight and performance provisions. Also, the use of traditional equipment such as knee pad, stopwatch, force gauge, etc., is appropriate for many tasks and their use is encouraged.

b. Takeoff.

(1) Regulations Reference. Sections 23.53 and 23.1587.

(2) Discussion.

(a) Measurement Methods. Section 23.51(a) requires the measurement of the distance required to takeoff and climb over a 50-foot obstacle. AC 23-8A, 19.b, describes acceptable methods of compliance. To avoid any inference that expensive test equipment is required, this advisory material provides additional guidance specifically applicable to small airplanes.

(b) Distance and Height Measurements and Equipment. Measurements should be taken to determine the distance from the takeoff starting point to the place where the aircraft leaves the ground and to the point where the airplane reaches the height of 50 feet. These measurements may be made in various ways. A few of the acceptable methods in general use follow:

1. When space-positioning equipment is not available, either of the following systems may be used. The first consists of several theodolites (sighting bars) spaced along the runway so as to cover the distance and time from takeoff point to the simulated 50-foot obstacle. The distance and time from takeoff point to each sighting station will give an approximation of the aircraft speed and takeoff distance. This method is shown schematically in figure 1.

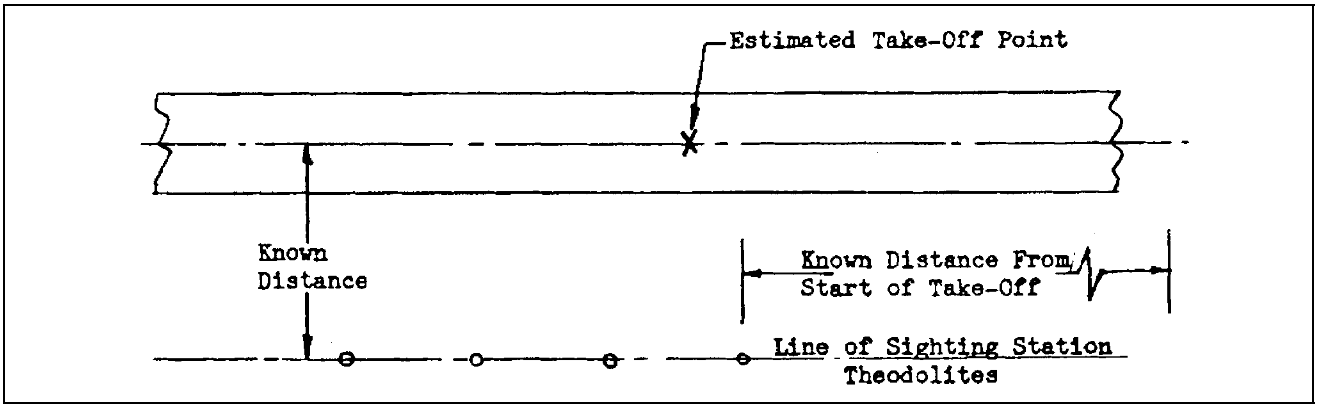

Figure 1 – SIGHTING BARS SPACED ALONG RUNWAY

It is good practice to station two or three observers at the edge of the runway in the vicinity of the takeoff point to mark the exact point of takeoff. The data obtained by such observers are always a good check on ground roll distance regardless of the method used for obtaining data. Additionally, the error in visually determining the takeoff point may be minimized by making a series of lime lines on the runway at 5- to 10-foot intervals in the expected takeoff zone. The transit should be tilted so that the plane of rotation of the sight intersects the vertical plane of the runway centerline at 50 feet. (The height of the aircraft above the runway may be obtained by a formula determined from figure 2.) During a takeoff run, the airplane is tracked by the transit. As the airplane passes up through the horizontal cross hairs of the transit sight, the transit is stopped. A ground observer may be waved into position on the runway below the cross hairs to note the distance; or a calibration of distance as a function of transit azimuth may be made, and the distance at 50 feet read directly. Using this method the height of the aircraft above the runway may be obtained by a formula determined from figure 2.

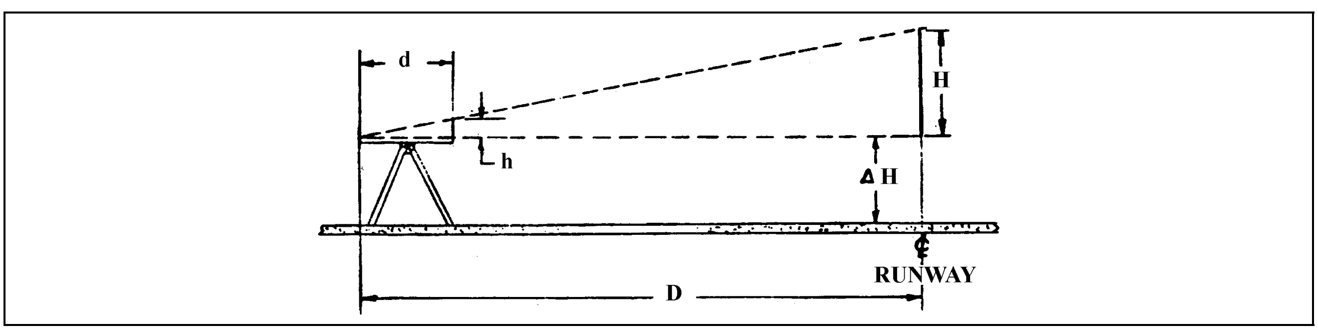

Figure 2 – FORMULA TO DETERMINE HEIGHT OF THE AIRCRAFT ABOVE RUNWAY

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A more accurate field method of obtaining takeoff data consists of a theodolite pivoted so it may track the aircraft during the takeoff run, figure 3.

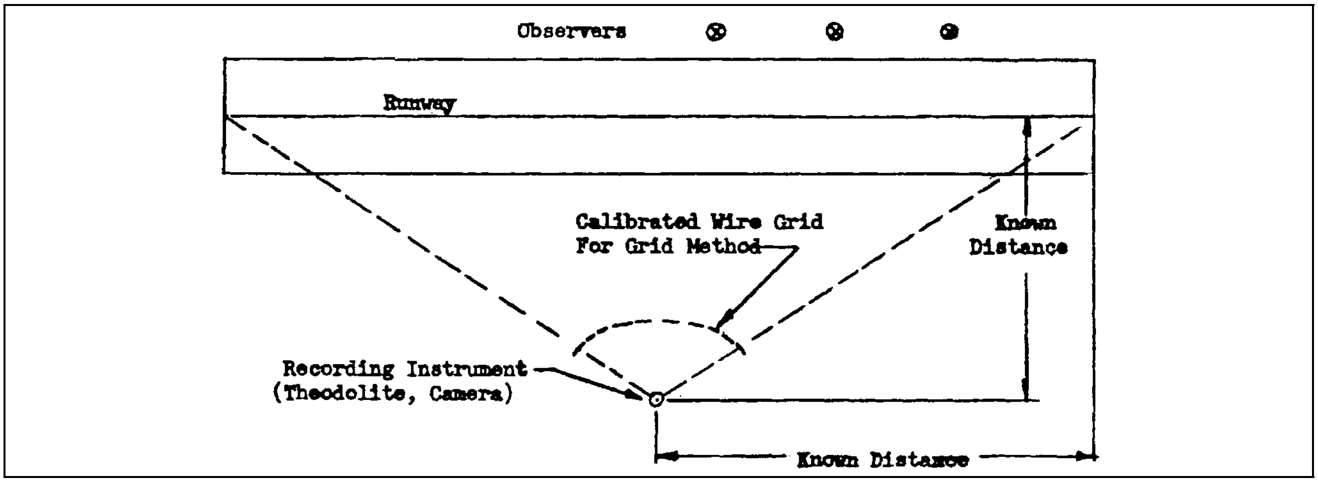

Figure 3 - TAKEOFF DATA INSTALLATION FOR
SWIVELING CAMERA OR RECORDING THEODOLITE

The theodolite is constructed in such a way that, by keeping cross hairs on the aircraft, a pencil trace of the aircraft position is placed on a chart fastened rigidly to the theodolite supports, or alternately, an electronic trace could be fed directly to a laptop computer. The swiveling theodolite is set up at a known distance from the runway and so aligned as to encompass only as much of the runway as will be necessary for the tests of the particular aircraft under consideration. This is done to obtain the greatest accuracy from the instrument.

Various standard distances from the runway may be arbitrarily determined and charts prepared in advance for use on this theodolite. A timing mechanism built into the sighting bar marks every second on the chart. Ground observers are used to mark the exact point of takeoff, and this information may be placed on the chart at the end of each test. A typical chart and takeoff graph is illustrated in figure 4.

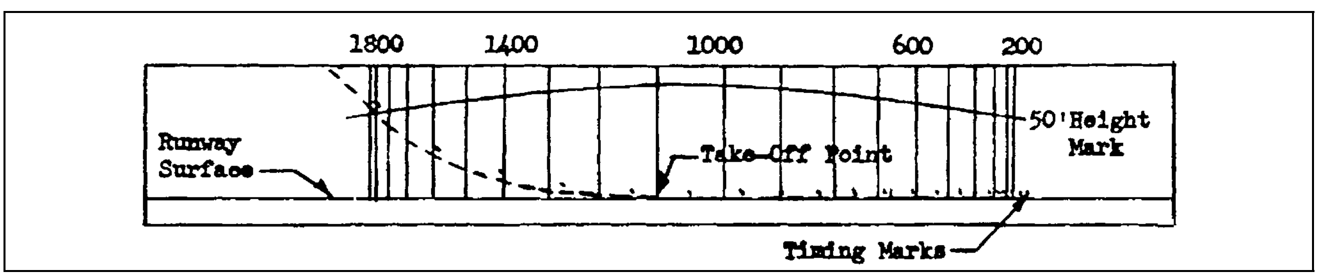

Figure 4 – TYPICAL CHART AND TAKEOFF GRAPH

2. A fixed grid may also be used to photographically record the tests. In this method, a grid consisting of a network of calibrated wires is placed in front of a video camera in the manner shown in figure 3, and at such a distance that it will remain in focus along with the airplane being tested. A timing device may be mounted on either the grid or camera to give a time history of the takeoff or landing. A typical frame taken through this type of grid is shown in figure 5.

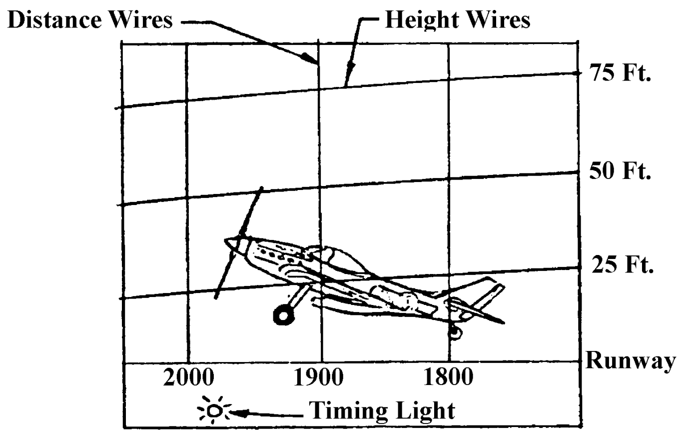

Figure 5 – FIXED GRID

3. From information obtained by any of the above methods in the previous section, the observed data may be plotted as in figure 6. This figure is usually included in the final report as is the corrected takeoff data.

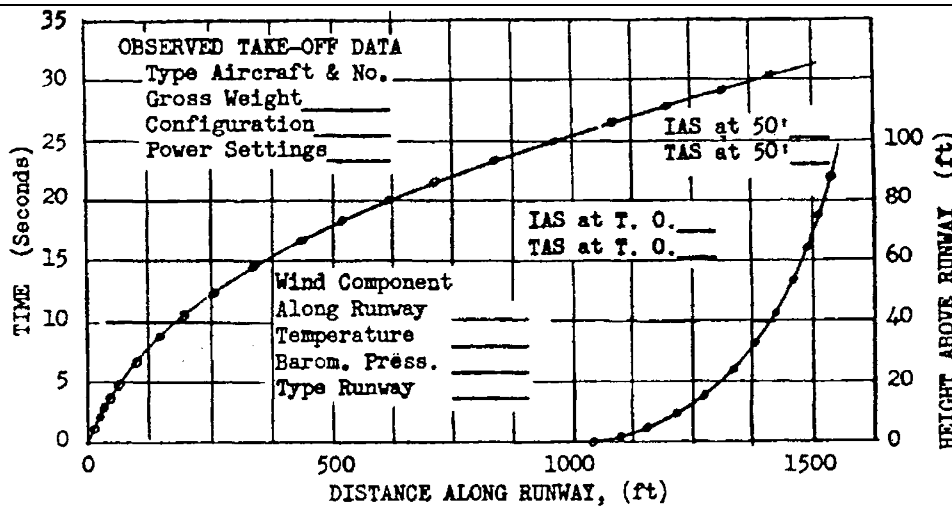

Figure 6 – CORRECTED TAKEOFF DATA

4. All takeoff performance data are corrected to sea level standard conditions and zero wind unless otherwise specified. A minimum of six takeoffs should be made and measured. Each test may be made using the appropriate speed over the obstacle.

(c) For simple airplanes equipped with reciprocating sea level engines, an acceptable data correction process to produce the takeoff distance for standard sea level no wind conditions is presented in figure 7.

Takeoff Distance - Segment Method (Acceleration Segment)

	Target Speed at 50 ft, V_{50}, KCAS	75		
1	Indicated Pressure Altitude, ft	3750	[recorded]	
2	Calibrated Pressure Altitude, ft	3750	[this example assumes that there is no difference between ind. and cal.]	
3	Obs. OAT, deg F	68	[recorded]	
4	St'd temp @ Alt_p, deg F (line 2)	46	[59 - .00356616 * line 2]	
5	Density Altitude @ line 2 and line 3, ft	5187	[((1 - 6.87535 * 10^{-6} * line 2) $^{5.2561}$ * (518.688 / (line 3 + 459.7))) $^{0.235}$ - 1] / (-6.87535 * 10^{-6})	
6	Density @ line 5	0.00212126	[0.0023769 * (1- ((6.87535 * 10^{-6}) * line 2) $^{4.2561}$]	
7	Density Ratio	0.89241259	[line 6 / 0.002377]	
8	Sq. root of density ratio in line 7	0.9447	[(line 7) $^{0.5}$]	
9	Obs. Comp. Wind Velocy (+ head - tail), knots	3.00	[record]	
10	Accelerate Airspeed for Test Cond. (TAS)	79.39	[V_{50} / line 7]	50' speed corrected for alt.
11	Accelerate Ground Spd. for Test Cond. (TAS)	76.39	[line 9- line 8]	50' speed corrected for alt. and wind.
12	Equivalent Altitude @ line 2 and line 3, ft	4267	[line 2 - (0.36 * (line 2 - line 5))]	
13	R/C @ V_{50} @ line 12, ft/min	450	[look up on equivalent alt. climb performance chart]	
14	R/C @ V_{50} @ S.L., ft/min	495	[look up on equivalent alt. climb performance chart]	
15	Accelerate Run Power Corr.	0.91	[line 13 / line 14]	
16	V_{50AIR} / V_{50GND}	1.04	[line 10 / line 11]	
17	Accelerate Run Wind Corr.	1.07	[(line 16) $^{1.85}$]	
18	Accelerate Run Density Corr. = line 7	0.89	[just the density ratio from line 7]	
19	Observed Accelerate Dist. to Speed @ line 11, ft	820	[record]	
20	Corr. S.L. Accelerate Dist. to V_{50}, ft	714	[line 19 * line 18 * line 17 * line 15]	
21	Average S.L. Accelerate Distance, ft	755	[average from total runs]	
	climb segment			
22	V_{50}, Speed @ 50 ft. std. S.L. , knots	77	[look up on climb chart]	
23	R/C @ V_{50} and std. S.L. , ft/min	495	[line 14]	
24	Horizontal Distance from Lift-off to 50 ft	789	[50ft *((line 22 * 1.69 * 60) / line 23)]	
25	S.L. Total Distance from Start to 50 ft , ft	1544	[line 21 + line 24]	ground distance to 50' speed + horizontal component (distance) to climb 50' taken from climb chart

Notes:

1. This chart is for sea level, std. day takeoff distance to 50'
2. Aircraft configuration, flaps and weight, should be specified
3. Landing gear is assumed down until after 50' point - if its determined that retracting the gear would significantly increase drag and therefore takeoff distance - a caution should be included in the handbook.

Figure 7 – DETERMINATION OF STANDARD S.L. TAKEOFF DISTANCE SEGMENT METHOD (ACCELERATION SEGMENT)

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The Takeoff Distance Segment Method (figure 7) is a simplified method to collect takeoff distance data to a 50-foot obstacle clearance height. This method is appropriate for simple airplanes because it is conservative and it does not require any elevation instrumentation to determine the 50-foot point. This method sums the ground acceleration, without any climb, to the point where the target obstacle clearance speed is achieved, with the horizontal distance to climb 50 feet.

A simple way to understand the takeoff distance segment method is to understand it in terms of work/energy. The total distance is the sum of the work/energy required to accelerate to the obstacle clearance speed without any climb and the work/energy required for a steady climb of 50 feet (out of ground effect). The data for the climb segment should be based on the data reduction used for climb testing. Airplanes with fixed pitch props should use the equivalent altitude method, whereas airplanes with constant speed propellers should use the density altitude method. Radio calls can allow ground observers to mark distances to planned liftoff and obstacle clearance speeds. This figure presumes the test to have been conducted within the +5/-1 percent weight tolerance of § 23.21, and that correction of off-standard weight is not necessary. For the same type of airplane, an acceptable method of determining the approximate effects of altitude and temperature upon takeoff distance is presented in figure 8.

	Determination of Takeoff Distance to 50 ft at Given Altitude and Temperature		
1	Indicated Pressure Altitude, ft	3750	[recorded]
2	Calibrated Pressure Altitude, ft	3750	[this example assumes that there is no difference between ind. and cal.]
3	Temperature, deg F	68	[recorded]
4	St'd temp @ Alt_P, deg F (line 2)	46	[59 - .00356616 * line **2**]
5	Density Altitude @ line **2** and line **3**, ft	5187	[((1 - 6.87535 * 10^{-6} * line **2**)$^{5.2561}$ * (518.688 / (line **3** + 459.7)))$^{0.235}$ - 1] / (-6.87535 * 10^{-6}
6	Density @ line **5**	0.002121	[0.0023769 * (1- ((6.87535 * 10^{-6}) * line **2**)$^{4.2561}$]
7	Density Ratio	0.892413	[line **6** / 0.002377]
8	Sq. root of density ratio in line **7**	0.9447	[(line **7**)$^{0.5}$]
9	Equivalent Altitude @ line **2** and line **3**, ft	4267	[line **2** - (0.36 * (line **2** - line **5**))]
10	V_{50}- Calibrated Airspeed, knots	76	[indicated corrected for instrument error]
11	R/C @ V_{50} @ line **9**, ft/min	450	[look up on equivalent alt. climb performance chart]
12	R/C @ V_{50} @ S.L., ft/min	495	
13	Accelerate Run Power Corr.	0.91	[line **13** / line **14**]
14	Distance to accelerate to $V_{50'}$ @ S.L.Std	755	[from the chart shown in fig. 7]
15	Distance to Accelerate to $V_{50'}$ at line **1** and line	931	[line **14** / (line **13** * line **7**)]
16	Distance to Climb to 50 ft	568	[(50 * 60 * line **10**) / (line **13** * line **7** * line **12**)]
17	Total Distance from Start to 50 ft.	1498	[line **15** + line **16**]

Figure 8 – DETERMINATION OF TAKEOFF DISTANCE TO 50 FEET AT GIVEN ALTITUDE AND TEMPERATURE

The correction process of figures 7 and 8 presume the acceleration distance to vary inversely as the excess thrust that exists at the 50-foot speed, rather than inversely with the "effective acceleration" which generally corresponds with a speed approximately 30 percent lower. This simplifying assumption enables use of the airplane's climb performance ratio as an approximate correction factor for the effect of altitude and temperature upon acceleration distance, and thereby avoids the need for thrust computations. However, the process is not considered to be valid for extrapolating performance to gross weights or wind conditions, which differ significantly from those of the test.

This method calculates total takeoff distance and not a ground run distance. Part 23 does not require any ground distance data for small airplanes; however, it would be helpful to the pilot to include the ground distance numbers that are determined using this method. The ground distance for sea level, standard day conditions at gross weight could be provided with correction factors for increasing altitude and temperature.

(d) Glossary of Terms**:**

H_p	-	Pressure Altitude	OAT	-	Outside Air Temperature
H_D	-	Density Altitude	σ	-	(sigma) Density Ratio
H_e	-	Equivalent Altitude	α	-	Runway Slope, in Degrees
R/C_{GU}	-	Rate of Climb, Gear Up	b	-	Wingspan
E	-	Oswald Efficiency Factor (.6 may be assumed in the absence of analysis or test)	g	-	Gravitational Constant

c. Climb.

(1) Regulations Reference. Sections 23.65 and 23.1587.

(2) Discussion. Section 23.65 requires the determination of climb performance, which exceeds a minimum standard. When AC 23-8A was published, it no longer included the previously longstanding equivalent altitude method of reducing climb data for fixed pitch propeller airplanes. The elimination of the equivalent altitude method of reducing climb data leaves no practical method for simple airplanes with fixed pitch propellers to reduce climb data.

The density altitude method of climb data reduction for constant speed propeller airplanes is still embodied in AC 23-8A.

For small airplanes, simplified methods are acceptable as follows:

(a) Equivalent Altitude. Data reduction procedures using the equivalent altitude method are an acceptable means of compliance for small airplanes with fixed pitch propellers. This method is described in National Advisory Committee for Aeronautics (NACA) Report 297. The data reduction form shown in figure 9 may be employed. This method is applicable to both saw tooth and continuous climb data sets. Full throttle operation is required for valid results.

Climbs – Equivalent Altitude Method

	Wing Span, b	33.30	
	Oswold Efficiency Factor, e	0.80	
1	Indicated Pressure Altitude	3750	[recorded]
2	Calibrated Pressure Altitude	3750	[this example assumes that there is no difference between ind. and cal.]
3	Obs. OAT, deg F	68	[recorded]
4	Obs. OAT, deg C	20	[(5 / 9) * (line **3** - 32)]
5	Indicated Airspeed	68	[recorded]
6	Calibrated Airspeed	70	[from A/S calibration charts]
7	Observed R/C, ft/min	442	[Altitude delta / time (minutes)]
8	St'd temp @ Alt_p, deg F (line 2)	46	[59 - .00356616 * line **2**]
9	ABS OAT, deg R,	528	[459.7+ line **3**]
10	ABS Std. temp., deg R	505.24	[518.688-(.00356616* line **2**]
11	Temperature correction	1.04	[line **9** / line **10**]
12	Density Altitude @ line **2** and line **3**	5187	[((1 - 6.87535 * 10^{-6} * line **2**)$^{5.2561}$ * (518.688 / (line **3** + 459.7)))$^{0.235}$ - 1] / (-6.87535 * 10^{-6})
13	Density @ line **12**	0.002121	[0.0023769 * (1- ((6.87535 * 10^{-6}) * line **2**)$^{4.2561}$]
14	(1 / (Sq. root density ratio)) at line **12**	1.1096	[1 / {(518.688 (1- (6.87535 * 10^{-6}) * line **2**)$^{5.2561}$) / (line **3** + 459.688)}$^{0.5}$
15	Test airplane wt.	1745	[recorded]
16	Weight Correction	0.99	[W_{STD} / line **15**]
17	True Airspeed	78	[line **6** * Line **14**]
18	Dynamic Pressure	13.81	[0.5 * line **13** * (line **17** * **1.467**)^2]
19	Calculation Factor	38471	[line **18** * pie * e * b^2]
20	Ind. Drag @ Test Wgt	79	[line **15**^{2} / line **19**]
21	del Di due to Wgt	-1.35	[line **20** * (line **16**^{2} - 1.0)]
22	R/C corr. for Wgt and Temp.	466	[(line **7** * line **11**)/ line **16**]
23	del R/C due to del Di	-5.36	[(line **21** * line **17** * 88) / W_s]
24	Equivalent Altitude	4267	[line **2** - (0.36 * (line **2** - line **12**))]
25	**R/C** [Std. Atm. @ Alt line 24] ft/min	471	[line **22** - line **23**]
	Standard Day R/C Expanded to Approximate Effects of Altitude and Temperature		
	Example is for 5000 ft at ISA plus 20 degrees C		
1	Pressure Altitude	5000	
2	OAT_S, deg C	5.15	[(line **1** * (-0.002)) + 15.15]
3	OAT_S, deg F	41.27	[((9 * line **2**) / 5) + 32]
4	OAT, deg C	25.15	[This is line 2 plus or minus the temperature value selected. For this example it is +20]
5	OAT, deg F	77	[((9 * line **4**) / 5) + 32]
6	ABS OAT_S, deg R	501	[line **3** + 459.7]
7	ABS OAT, deg R	537	[line **5** + 459.7] 0.832
9	Temp. correction:	0.93	[line **6** / line **7**]
10	Pressure Ratio	0.871714	[1 - ((6.87535 * 10^{-6}) * line 2))$^{5.2561}$]
11	Density @ Alt_p and OAT in lines 1 &	0.001933	[line **9** * 0.002377 * line **10**]
12	$Alt_{density}$, @ Alt_p and OAT in lines 1 &	7280	[Look up from std. atmosphere tables.]
13	Equivalent Altitude	5821	[Go to the std. day climb performance plot and use the performance at **5821 ft**
			for the performance at 5000 ft and 20 deg C above ISA (warmer day)]
	Expand for the Approximate Effects of Weight: (This is optional for airplanes under 6000 pounds unless they have a turbine engine)		
14	Density Ratio	0.813272	[line **11** / 0.002377]
15	1 / (sq root density ratio)	1.108874	[1 / (line **14**)$^{0.5}$]
16	Airplane Weight, **Selected**	1500	[self-explanitory]
17	Weight Correction	1.15	[Gross weight / Line **16 selected wight**]
18	V_{climb} , mph	61.00	[recommended climb speed]
19	TAS	67.64	[line **18** * line **15**]
20	Dynamic Pressure	7.74	[0.5 * line **11** * (line **18** *1.467)^2]
21	$Drag_{induced}$ @ Selected Weight	104.36	[line **16**^{2} / (3.14 *b^2 * e * line **20**)]
22	del Drag Due to Weight	34.46	[line **21** * ((line **17**^{2}) - 1)]
23	delta Rate of Climb, ft/min	96.44	[(2 / (3.14 * b^2 * e * line **11** * (line **19** * 1.467)) * ((1730^2) - (line **16**^{2})) / 1730) * 60]

Figure 9 – DATA REDUCTION FORM CLIMBS – EQUIVALENT ALTITUDE METHOD

The essential limitation to this method is that the correction to the observed climb for power, when the outside air temperature is not standard, is predicated upon the assumption that all engine controls are fixed. That is, no correction for variation in throttle setting, mixture, carburetor heat, etc., is made, and a climb at any part throttle setting is corrected for that throttle setting but not to full throttle. This method is referred to as the "equivalent altitude method" since it employs a correction to climb performance test data for atmospheric temperature variations from "standard" which indicates that the performance obtained under any atmospheric temperature and pressure may be obtained at some "equivalent altitude" in the standard atmosphere. The "equivalent altitude" may for the purposes of this AC be expressed as the "pressure" altitude plus 0.36 times the algebraic difference between the "density" altitude and the observed "pressure" altitude ("equivalent" altitude will always lie between the "pressure" altitude and the "density" altitude). As mentioned above, when climb performance is referred to "equivalent" altitude, no further correction for the effect of power changes needs to be made, and the final climb obtained thereby is that which would be obtained in the "standard atmosphere" at a height equal to the "equivalent" altitude when the power plant is operated as it was in the actual test.

(b) Density Altitude. Data reduction procedures using the density altitude method are an acceptable method of compliance for small airplanes with constant speed propellers. This method is outlined in AC 23-8A. The data reduction form shown in figure 10 may be employed. This method also is applicable to both saw tooth and continuous climb data sets.

FORM ACE-1762
FORMERLY FAF-17
(1-2-47)

CLIMB CORRECTION - SHEET 1

DEPARTMENT OF COMMERCE
CIVIL AERONAUTICS ADMINISTRATION

AIRPLANE	ENGINE				PROPELLER	PAGE
MODEL	MODEL				MODEL	
STD. WT.	RATING	T.O.	RPM		BLADE	
PROV. WT.		METO	RPM			
WING AREA	GEAR RATIO				NO. BLADES	REPORT NO.
SPAN						
"E"	MIN. OCTANE				TYPE	
"F"						
ENG. COWL FLAP OPENING	CRIT. ALT. (RATED)				DIA	FLIGHT NO.
CONFIGURATION	CRIT. ALT. (TEST)					

NO.	ITEM		CLIMB NO.	CLIMB NO.	CLIMB NO.	CLIMB NO.	CLIMB NO.
1	INDICATED AIRSPEED	(MPH)					
2	TRUE INDICATED AIRSPEED	(MPH)					
3	$\sqrt{\rho/\rho_o}$						
4	TRUE SPEED = (2) /(3)	(MPH)					
5	TIME	(MIN)					
6	OBSERVED CLIMB	(FT.)					
7	OBSERVED RATE OF CLIMB R/C	(FT./MIN.)					
8	AVERAGE PRESSURE ALTITUDE H_p	(FT.)					
9	OBSERVED OUTSIDE AIR TEMP.	(°F)					
10	ABSOLUTE OBS. OUTSIDE AIR TEMP.	(°F)					
11	STANDARD AIR TEMP. AT ALT. (8)	(°F)					
12	ABS. STAND. AIR TEMP. AT ALT. (8)	(°F)					
13	DENSITY ALTITUDE H_D	(FT.)					
14	STAND. AIR TEMP. AT ALT. H_D (13)	(°F)					
15	ABS. STAND. AIR TEMP. AT H_D (13)	(°F)					
16	OBSERVED CARB. AIR TEMP.	(°F)					
17	ABSOLUTE CARB. AIR TEMP.	(°F)					
18	CARB. HEAT RISE = (16) - (9)	(°F)					
19	OBSERVED ENGINE RPM	(RPM)					
20	OBSERVED MANIFOLD PRESSURE	(in. H_g)					
21	ACTUAL WEIGHT	(LBS.)					

Figure 10 – DATA REDUCTION FORM CLIMBS – DENSITY ALTITUDE METHOD
(SHEET 1 OF 2)

FORM ACE-1762
FORMERLY FAF-17
(1-2-47)

CLIMB CORRECTION - SHEET 2

NO.	ITEM	CLIMB NO.	CLIMB NO.	CLIMB NO.	CLIMB NO.	CLIMB NO.
22	$\frac{\text{ABS. OUTSIDE AIR TEMPERATURE}}{\text{ABS. STAND. AIR TEMP. }(H_P)} = \frac{(10)}{(12)}$					
23	$\sqrt{\frac{\text{ABS. STD. AIR TEMP. }(H_P)}{\text{ABS. CARB. AIR TEMP.}}} = \sqrt{\frac{(12)}{(17)}}$					
24	$\sqrt{\frac{\text{ABS. STD. AIR TEMP. AT }H_D}{\text{ABS. STD. AIR TEMP. AT }H_D + \text{CAHR}}} = \sqrt{\frac{(15)}{(15)+(18)}}$					
25	$\frac{\text{ACTUAL WEIGHT}}{\text{WT. TO BE CORRECTED TO}} = \frac{(21)}{(W_F)}$					
26	$\frac{(\text{WT. TO BE CORRECTED TO})^2}{(\text{ACTUAL WEIGHT})^2} - 1 = \frac{1}{(25)^2} - 1$					
27	ENGINE POWER FROM POWER CURVE (HP)					
28	ACTUAL BRAKE HORSEPOWER = (27) X (23) (HP)					
29	STD. BHP ATTAINABLE AT H_D (HP)					
30	BHP OBTAINABLE AT H_D = (29) X (24) (HP)					
31	ACTUAL RATE OF CLIMB OF TEST AT TEST WT. & STANDARD COND. = (7) X (22) (FT./MIN.)					
32	η - PROPULSIVE EFFICIENCY					
33	BHP_A CHANGE-ACTUAL TO THAT AT H_D = [(30) - (28)] (HP)					
34	THP_A CHANGE-ACTUAL TO THAT AT H_D = (32) X (33) (HP)					
35	INDUCED POWER REQ. AT TEST WT. $(HP_{RI}) = \frac{(21)^2}{3.013eb^2 \times (3) \times (2)}$ (HP)					
36	INCREMENT OF INDUCED POWER REQUIRED CHANGE-FROM TEST WT. TO FINAL WT. AT CONSTANT SPEED = - (35) X (26) (HP)					
37	THP CHANGE DUE TO HP CHANGES OF (34) + (36) AT FINAL WT. = (34) + (36) (HP)					
38	R/C CHANGE DUE TO HP CHANGES OF (37) A_T FINAL WT. = (37) x $\frac{33,000}{W_F}$ (FT./MIN.)					
39	TEST R/C COR. TO W_F = (31) X (25) (FT./MIN.)					
40	FINAL R/C AT W_F + H_D(STAND) = (38) + (39) (FT./MIN.)					

Figure 10 – DATA REDUCTION FORM CLIMBS – DENSITY ALTITUDE METHOD (SHEET 2 OF 2)

(c) Engine Power Correction. These methods make no direct engine power corrections for the difference between calibrated and rated power. The determination of the "equivalent" altitude empirically adjusts the data to allow for atmospheric effects on power for fixed pitch propeller installations. If further corrections for engine power (differences between calibrated and rated power) are desired, the following process may be utilized for either the equivalent or density altitude method:

1. The airplane climbs because a surplus of power is available in accordance with the relationship,

$$R/C = \eta_p \times BHP_{ex} \times 33000/W$$

where,

R/C = rate of climb, feet/minimum

η_p = propulsive efficiency (.75 may be used for constant speed propellers and .65 for fixed pitch propellers if no better value is known)

BHP_{ex} = excess brake horsepower available

W = aircraft weight, pounds

2. To develop a power correction, the above equation is solved for,

$$BHP_{ex} = \left(R/C \times W\right) \div \left(\eta_p \times 33000\right)$$

where,

R/C = sea level rate of climb developed in flight test

W = airplane approved gross weight

Also,

$$BHP_{ex} = BHP_{avail} - BHP_{req}$$

where,

BHP_{avail} = maximum power available at sea level at the manifold pressure and engine rpm, which can be achieved.

BHP_{req} = power required for level flight at the climb speed.

The power correction must be applied to the BHP_{avail} term. For example, the calibrated engine produces 101 percent rated power, then the BHP_{avail} must be reduced by 1 percent.

Therefore,

$$BHP_{ex_{corr}} = \left(BHP_{avail} - CORR\right) - BHP_{req}$$

where,

$BHP_{ex_{corr}}$ = excess power remaining following the power correction

$CORR$ = power correction to available power

Using the corrected excess power, resolve the original equation to obtain the corrected rate of climb,

$$R/C_{corr} = \eta_p \times BHP_{ex_{corr}} \times 33000 \div W$$

(d) Data Requirements. In order to provide AFM data showing the effect of altitude and temperature as required by § 23.1587, a sufficient number of climbs through a range of speeds must be completed allowing rate of climb to be plotted against equivalent or density altitude (whichever is appropriate). This relationship is then used to produce the AFM performance information. It is also necessary to perform climbs at different speeds in order to determine the best rate of climb speed V_Y.

d. Landing.

(1) Regulations Reference: Sections 23.75 and 23.1587.

(2) Discussion.

(a) Measurement Methods. Section 23.75 requires the measurement of the distance required to land over a 50-foot obstacle and come to a stop. The methods described for takeoff measurement are equally applicable for landing performance measurements.

(b) Data Reduction. A number of ways exist to correct the test data obtained above to standard conditions at sea level. One method that has been used is shown in figure 11. These forms are oriented for reduction of test data obtained by photographic methods but may be adapted to other data collection methods.

TITLE ____________ PAGE ____________

PREPARED BY ____________ DATE ____________ REPORT NO. ____________

CHECKED BY ____________ DATE ____________ MODEL ____________

CORRECTION OF LANDING DATA TO STANDARD CONDITIONS

	LANDING NUMBER		1	2	3	4
1	W_T = ACTUAL TEST WEIGHT	(LBS.)				
2	W_F = WEIGHT TO BE CORRECTED TO	(LBS.)				
3	W_T/W_F = (1) / (2)					
4	H_P = PRESSURE ALTITUDE @ GROUND DURING TEST	(FT.)				
5	OAT = TEMPERATURE AT GROUND DURING TEST	(°F)				
6	H_D = DENSITY ALTITUDE	(FT.)				
7	ρ = DENSITY @ (4) + (5)	(SLUGS/FT.^{3})				
8	ρ_F = DENSITY TO BE CORRECTED TO	(SLUGS/FT.^{3})				
9	(7) / (8)					
10	T_A = AIR TIME FROM 50 FT. TO GROUND (CAMERA DATA)	(SEC.)				
11	V_{WO} = OBSERVED WIND VELOCITY	(FT/SEC.)				
*12	V_{WH} = 1.376 (11) = WIND VELOCITY AT 50 FT.	(FT./SEC.)				
13	V_{HO} = OBSERVED VELOCITY @ 50 FT. (CAMERA DATA)	(FT./SEC.)				
14	V_H = (12) + (13) = TRUE AIRSPEED AT 50 FT.	(FT./SEC.)				
15	V_{CO} = OBSERVED CONTACT VELOCITY (CAMERA DATA)	(FT./SEC.)				
16	V_{CA} = (11) + (15) = TRUE AIRSPEED AT CONTACT	(FT/SEC.)				
17	V_{CA}/V_{CO} = (16) / (15)					
18	$(V_{CA}/V_{CO})^{1.85} = (17)^{1.85}$ = WIND CORRECTION FOR GROUND RUN					
19	V_{VH} = OBSERVED VERTICAL VELOCITY @ 50 FT.(CAMERA DATA)	(FT/SEC.)				
20	1.210 (14) + (16)					
21	$.00575 \frac{(14) \times (20)}{(19)}$					
22	1.185 (10)					

* Assuming $V_{WH} = \left(\frac{56}{6}\right)^{1/7} V_{WO}$

Figure 11 - DATA REDUCTION FORM
CORRECTION OF LANDING DATA TO STANDARD CONDITIONS (SHEET 1 OF 2)

TITLE		PAGE	
PREPARED BY	DATE	REPORT NO.	
CHECKED BY	DATE	MODEL	

CORRECTION OF LANDING DATA TO STANDARD CONDITIONS

	LANDING NUMBER	1	2	3	4
23	(11) ((22) + (21)) = AIR RUN CORRECTION FOR WIND (FT.)				
24	$V_H = 1.3\ V_{STALL}$ @ $H_D = 1.3 \times 1.467\ V_{S_O}\sqrt{1/(3)} \times \sqrt{\rho_o/(7)}$ (FT./SEC.)				
25	$(24)^2 - (16)^2 + 3220$				
26	$(14)^2 - (16)^2 + 3220$				
27	(25) / (26) = AIR RUN CORRECTION FOR APPROACH SPEED				
28	$(14)^2 + 3220$				
29	$\frac{(28)}{(3)\,(14)^2 + 3220}$ = WEIGHT CORRECTION FOR TOTAL RUN				
30	$\frac{(28)}{(14)^2/(9) + 3220}$ = DENSITY CORRECTION FOR TOTAL RUN				
31	S_{A_O} = MEASURED AIR DISTANCE (CAMERA DATA) (FT.)				
32	S_{G_O} = MEASURED GROUND DISTANCE (CAMERA DATA) (FT.)				
33	$(15)^2/[(15)^2 \pm (32)2gSIN\alpha]$ = RUNWAY SLOPE CORR				
34	S_{A_1} = [(31) + (23)] (29) (30) = CORR. AIR DIST. @ TEST APPROACH SPEED, (FT.)				
35	S_{A_2} = (34) (27) = CORR. AIR DISTANCE @ 1.3 V_{S_O} APPROACH SPEED, (FT.)				
36	S_G = (32) (18)(29)(30)(33) = CORRECTED GROUND DISTANCE FT.				
37	S_{T_1} = (34) + (36) = CORRECTED TOTAL DISTANCE @ TEST APPROACH SPEED, (FT.)				
38	S_{T_2} = (35) + (36) = CORRECTED TOTAL DISTANCE @ 1.3 V_{S_O} APPROACH SPEED, (FT.)				

Figure 11 - DATA REDUCTION FORMCORRECTION OF LANDING DATA TO STANDARD CONDITIONS (SHEET 2 OF 2)

e. Balked Landing.

(1) Regulation Reference. Section 23.77.

(2) Discussion.

(a) The equivalent altitude method of climb performance data reduction may be used for airplanes with fixed pitch propellers. The discussion under § 23.65 applies.

(b) For reduced testing requirements, the following process may be employed:

1. At a convenient altitude, in smooth air, conduct climbs through the same altitude band in opposite directions at the same speed. These climb segments should be of

approximately three minutes duration (subject to engine cooling restraints). Climbs should be performed perpendicular to reported winds at test altitude. Altitude should be recorded at 30-second intervals.

2. Reduce these climb data by the equivalent altitude method and average the two rates of climb.

(c) Ensure the climb gradient equals or exceeds 1:30, as required in § 23.77.

f. Longitudinal Control.

(1) Regulations Reference. Sections 23.145, 23.161, and 23.677(b).

(2) Discussion. Sections 23.145(e)(1), 23.161, and 23.677(b) together have been interpreted to require an elevator trim tab system or an elevator trim system totally independent from the elevator control system. To ensure that a tab system is flutter free with the disconnection of a control element in the tab system (as required by § 23.629(f)), a fully redundant tab control system back to the trim control is effectively required. For small airplanes, the following simplified methods are permitted:

(a) A longitudinal control system that provides trim control through a bungee system connected to the elevator horns complies with this rule.

(b) A bungee trim system attached not to the elevator horn, but to a pushrod, or pushrods, connected to the elevator also comply with the rule.

g. Static Longitudinal Stability.

(1) Regulation Reference. Section 23.175.

(2) Discussion: Stick force curve requirements are specified by § 23.175, but need not be measured with instruments if changes in speed are clearly reflected by changes in stick forces.

Because of the relatively small speed and center of gravity (CG) envelopes, a simplified matrix of the configurations to be tested is an acceptable method of compliance. Additional guidance is available in AC 23-8A.

(a) Compliance with the rule may be met by a qualitative assessment of stick force gradients by the test pilot for the following matrix of flight conditions. Tests should be conducted at the most critical weight and CG with gear extended. For light aircraft, the most critical condition is usually lightweight and aft CG.

1. Section 23.175(a) Climb - flaps up, gear up, 75 percent power, trimmed to V_y;

2. Section 23.175(b) Cruise - flaps up, gear up 75 percent power, trimmed for level flight; and

3. Section 23.175(c) Approach/Landing - landing flaps, power idle, trimmed to the recommended landing approach speed. Repeat with power for a three-degree descent.

(b) For any of these four conditions where stability is marginal, as determined by the test pilot, the stick force gradient must be measured.

For example, if stability in climb at aft CG were the only marginal stability flight condition, a measurement of stick force gradient with pertinent comments in this condition would comply with the rule.

h. Stall.

(1) Regulations Reference. Sections 23.201 and 23.203.

(2) Discussion. Compliance may be shown by qualitative test pilot assessments. On airplanes without gyros, a flat Plexiglas plate over the glare shield on which the test pilot can mark bank angles with a grease pencil may be used to substantiate bank angles.

(a) Test pilot notation of altitude loss may be from observations of a standard altimeter.

(b) A Plexiglas plate with incremental bank angles placed over the glare shield and a video camera may be used to record bank angles.

(c) Compliance may be shown by rational analysis with testing at forward CG for stall speed determination and aft CG for stall characteristics determination.

i. Stall Warning.

(1) Regulation Reference. Section 23.207.

(2) Discussion. Compliance with this rule for small airplanes is found where the stall warning begins at not less than five knots above stall speed. The upper limit for stall warning must not produce a nuisance.

j. Spin.

(1) Regulation Reference. Section 23.221.

(2) Discussion. AC 23-8A, with or without the following modification, is considered an acceptable method of compliance for small airplane spin testing.

(a) Modifications of AC 23-8A, Provisions. The following modifications of AC 23-8A,paragraphs are accepted for application to normal category spin substantiation:

<u>1</u>. b(1) <u>Weight and CG Envelope</u>. For normal category spins, the corners of the approved loading envelope should be tested.

<u>2</u>. b(3) <u>Control Deflections</u>. For airplanes with rigging tolerances specified as +/-1 degree or less, control surface rigging may be set to nominal specifications. For airplanes with rigging tolerances specified as greater than +/-1 degree, tests should be conducted at nominal specifications; and if any spin configuration is found to be critical, then the effects of rigging should be investigated for that condition.

<u>3</u>. b(9) <u>Trimmable Stabilizer</u>. The effect of the trimmable stabilizer on spins should be determined for the critical conditions with the trim set for 1.5 V_{S1} in the cruise configuration, 1.2 V_{S1} in the takeoff configuration, and 1.3 V_{S1} in the landing configuration.

<u>4</u>. c(3) <u>Recovery From Spins Following Abnormal Control Usage During Entry and Recovery</u>. The provisions of this paragraph should be applied as necessary based on the outcome of the testing conducted in paragraph <u>5</u>c(4).

<u>5</u>. c(4) <u>Spin Matrix</u>. Add the following to this paragraph after the present first sentence:

> The airplane configurations to be evaluated should correspond to the configurations expected to be used for takeoff, cruise, and landing. For a normal category airplane, the spin test matrix should cover those abnormal control inputs reasonably expected from a pilot experiencing an inadvertent spin entry such as forgetting to reduce power, reflexively applying anti-spin aileron (against the turn) in response to roll-off, or inadvertently reversing recovery rudder and elevator sequencing. The “Normal Category Spin Test Matrix” is an acceptable method of compliance, unless unusual response requires additional exploration (see figure 12).

NORMAL CATEGORY SPIN TEST MATRIX

Configuration*

Normal Spins	Level Entry	Left (Lt) Turn	Right (Rt) Turn
Clean, Power Off	1 Lt, 1 Rt	1 Lt, 1 Rt	1 Lt, 1 Rt
Takeoff, Power On	1 Lt, 1 Rt	1 Lt, 1 Rt	1 Lt, 1 Rt
Landing, Power Off	1 Lt, 1 Rt	1 Lt, 1 Rt	1 Lt, 1 Rt
Abnormal Spins	**Power On Ailerons Against**	**Power Off Ailerons Against**	**Power Off Elevator 1st Recovery**
Clean	1 Lt, 1 Rt	1 Lt, 1 Rt	1 Lt, 1 Rt
Takeoff	1 Lt, 1 Rt	1 Lt, 1 Rt	1 Lt, 1 Rt
Landing	1 Lt, 1 Rt	1 Lt, 1 Rt	1 Lt, 1 Rt

*For normal category airplanes, the configurations to be examined are defined as follows:

Clean	Flaps up Gear up Cowl flaps closed
Takeoff	Flaps at maximum approved to takeoff setting Gear down Cowl flaps open
Landing	Flaps full down Gear down Cowl flaps closed

Each of these configurations should include testing at the combination of weight and CG determined to be most critical for the proposed loading envelope.

Figure 12 - NORMAL CATEGORY SPIN TEST MATRIX

6. c(5) Unrecoverable Spin. Any spin that cannot be recovered within the required spin criteria.

(b) Additional Guidance: Spin Resistant Airplanes. The following guidance on the application of the new § 23.221(a)(2) spin resistant provision is provided:

1. In § 23.221(a)(2)(ii), "with the ailerons deflected opposite the direction of turn in the most adverse manner" means anti-spin or "reflexive" ailerons.

2. In § 23.221(a)(2)(ii), "respond immediately" means recovery in approximately one-quarter turn or that amount that the test pilot determines is immediate and repeatable.

k. Emergency Landing Dynamic Conditions.

(1) Regulations Reference. Section 23.562.

(2) Discussion.

(a) See AC 23.562-1 “Dynamic Testing of Part 23 Airplane Seat Restraint Systems and Occupant Protection” for information. AC 23.562-1 addresses all part 23 airplanes, and has no specific guidance for “small, simple, low performance airplanes”. However, all of the guidance material may be applied to “small, simple, low performance airplanes”.

(b) See AC 23-11A “14 CFR Part 23 Type Certification of an Airplane Originally Certificated to Joint Aviation Regulations - Very Light Airplane (JAR-VLA) Standards”. Some small, simple, low performance airplanes, are similar to the JAR-VLA discussed in AC 23-11A, and therefore, that AC's guidance material may be of interest to the reader.

l. Fabrication Methods.

(1) Regulation Reference. Section 23.605.

(2) Process Specifications Format. The following sample process specification (for welding) provides an acceptable format. An applicant may develop specifications in this format.

(a) 1.0 PURPOSE

This section should cover what the specification will control. Such as,

> This specification establishes the engineering requirements for __name process__ to be used by __company name__. Personnel and machines used shall be able to meet or exceed this specification.

(b) 2.0 REFERENCES

The following publications are to be used to clarify this specification or be the basis for testing or equipment/personnel certification:

> List other company specifications, military specifications (MIL SPEC) or standards."

(c) 3.0 STANDARDS

3.1 Weld word vocabulary reference AWS A3.0-8 for definitions used in weld related work.

3.2 Examples of acceptable and unacceptable weld should be shown in this section.

3.3 Method of certification and recertification of the welder. Weld specimens and qualification and requalification test conditions.

3.4 Visual and radiographic inspection, metallographic examination and standards should be included in this section as applicable.

(d) 4.0 QUALIFICATION, CERTIFICATION, REQUALIFICATION, AND RECERTIFICATION

The ability to weld or inspect to the requirement of this specification shows the person, process, and equipment are qualified. "Certified," means the welder, welding procedure, and welding machine is qualified to make welds, and can make welds, to this specification.

4.1 Qualification requirement.

4.2 Equipment, machines, and process procedures should consist of such things as required tooling, welding, schedule, pre-heat cycles, post-heat cycles, and required calibration of equipment.

(e) 5.0 MATERIALS

5.1 List welding rod and electrodes.

5.2 Gases.

5.3 Storage of rods and electrodes.

(f) 6.0 TECHNICAL

6.1 Inspection and manufacturing requirements.

6.2 Pre-heat and post-heat requirements if needed.

6.3 Heat treatment. This paragraph should cover any heat treatment required to restore all material in a weldment to a certain temper or tensile strength.

6.4 Detail gap - joint design information.

6.5 Describe weld repairs if applicable.

6.6 Cleaning, pre- and post-welding.

(g) 7.0 MANUFACTURING AND QUALITY CONTROL

7.1 Manufacturing requirements.

7.2 Quality control requirements.

m. Flutter.

(1) Regulation Reference. Section 23.629.

(2) Discussion. For general guidance on this section see AC 23.629-1A.

(3) Regulation Reference. Section 23.629 (b).

(4) Discussion. All airplanes certified to Title 14 CFR part 23, in any category, must perform flight flutter test(s) to show compliance in addition to any analytical methods.

(5) Regulation Reference. Section 23.629(d).

(6) Discussion. Airplanes that are the subject of this AC would typically meet the requirements of § 23.629(d)(1) through (d)(3). However, the applicant should review the criteria to ensure applicability. Based on the review of criteria, Engineering Report No. 45 (Simplified Flutter Prevention Criteria) could then be used to substantiate this portion of the regulations.

(7) Regulation Reference. Section 23.629(f)(2).

(8) Discussion. For small low performance airplanes, designing the actuating structures to a factor of safety equaling four and providing redundant fastener safety as a means to minimize loss of single fastener joint integrity would be an acceptable method of showing compliance with this request.

n. Proof of Strength (Wings).

(1) Regulation Reference. Section 23.641.

(2) Discussion. Section 23.641 requires proof of strength of a stressed skin wing through tests or by combined structural analysis and load tests.

Proof of strength of conventional aluminum or wood stressed skin wing structures primarily by analysis to limit and test to ultimate loads for the most critical bending and torsional wing load conditions is acceptable.

In order to determine the most critical bending and torsional wing loads, one must complete a loads survey of the structure to determine which load case(s) produce the lowest safety margin against catastrophic failure of the wing. The actual mechanics of how to determine those specific load conditions requires qualified and experienced engineering personnel. The critical load conditions must be determined for the specific structural and airplane configuration, by detailed load and stress analysis. A specific explanation of this procedure that would be applicable for every airplane design, doesn’t exist.

For conventional aluminum materials, the ultimate strength is typically less than one and a half times the yield strength. This means that as long as the article doesn't fail at the ultimate load, it will not yield at limit load. This rationale is for the worst-case scenario where the part fails in tension. For most structures however, failures occur due to instability first. The allowable ultimate load capability of a member in compression is lower than the tension capability. This further reduces the difference between the ultimate and yield strength. Structural analysis should still be used to demonstrate that the yield strength is not exceeded at limit loads. If non-conventional aluminum is used, where this yield-to-ultimate strength relationship doesn't exist, then testing to ensure no yielding occurs at limit loads may be in order, at the ACO's discretion.

In any event, part 23.307 is still applicable. Section 23.307 states in part that “Structural analysis may be used only if the structure conforms to those for which experience has shown this method to be reliable.” If in the ACO's judgment, the structure or analysis techniques used by the applicant, will not produce reliable analytical data, then testing may be in order.

For wooden structures, there are no well-defined (published) yield strength values. When you observe the stress-strain curves for wood, it is evident that the relationship is not linear up to failure. The mechanism, that appears as yielding on the stress-strain curve, is actually micro cracks that develop within the matrix (lignin) between the fibers (cellulose). This behavior is very similar to that exhibited by newer composite materials (graphite/epoxy). These micro cracks have a negligible effect on the final ultimate strength, stiffness, or fatigue properties of the material. Experience has shown that the ultimate strength test along with analysis is adequate to show compliance.

o. Landing Gear.

(1) Regulations Reference. Sections 23.723, 23.725, 23.726, and 23.727.

(2) Discussion. The designer selects the landing load factor, and the applicant is required to demonstrate that the airplane will not exceed this factor when the aircraft is landing at the descent velocity specified by the regulations (reference § 23.473). For design purposes, this load factor may not be less than 2.67 and must not be exceeded by the certification drop tests specified in §§ 23.723 through 23.727.

Alternatively, a conservative approach may be chosen by using a load factor of 4.2 g's to directly determine the static loads to be applied through design or static test to the landing gear. This load factor is considered conservative enough that it is unnecessary to verify it is not exceeded by an instrumented drop test. If this method (load factor of 4.2g's) is used, the only dynamic test required is the most critical drop test for reserve energy either in a fixture or by dropping the airframe, as described in § 23.727, without the need for instrumentation.

p. Brakes.

(1) Regulation Reference. Section 23.735.

(2) Discussion.

(a) A conservative rational analysis (§ 23.735(a)(1)), or Technical Standard Order (TSO) type tests (§ 23.735(a)(2)) and takeoff power test (§ 23.735(b)) are adequate for this class of airplane. (A rational analysis may include data such as service history, similarity to other approved brakes, etc., sufficient to increase the FAA's confidence level prior to installation/flight testing.)

(b) Additionally, taxi and landing stop tests to demonstrate acceptable longitudinal and directional stability and control, and that no unacceptable vibrations, squeal, fade, grabbing, or chatter are present, are required in accordance with §§ 23.75, 23.143(a)(6), 23.231(a), 23.233(c), 23.493(c), 23.1301(d), and 23.1309(a)(1).

NOTE: "Acceptable" means controllable by the average pilot.

q. Compartment Interiors/Powerplant Instruments.

(1) Regulations Reference. Sections 23.853 and 23.1337.

(2) Discussion. Section 23.853(e) does not prohibit direct reading oil pressure gauges, but it must be ". . . adequately shielded, isolated, or otherwise protected so that any breakage or failure of such an item would not create a hazard." Additionally, § 23.1337(a)(2)(i) and (ii) state that, "Each line . . . must have restricted orifices or other safety devices at the source of pressure to prevent the escape of excessive fluid if the line fails; and be . . . located so that the escape of (such) fluid would not create a hazard."

A direct oil pressure gauge line located in the cabin and fitted with an orifice of approximately 0.060-inch diameter located at the engine fitting limiting the flow of the oil into the cabin in the event of an oil line rupture inside the cabin is acceptable without a shrouded oil line vented overboard.

r. Fire Protection of Flight Controls, Engine Mounts, and Other Flight Structure.

(1) Regulation Reference. Section 23.865.

(2) Discussion. Two methods are available to validate that flight controls, engine mounts, and other flight structure can satisfy this requirement:

(a) Verify that the proposed components use a known fireproof material (example, steel or stainless steel). Or, as an alternative, a conformity inspection comparing the proposed assembly to an existing Parts Manufacturer Approval (PMA) or product that is used in an existing type certificated aircraft can be accomplished.

(b) The applicant can validate components not previously approved by performing a fireproof test. Procedures for conducting such tests are contained in AC 20-135. A proposed test plan would need to be reviewed and approved by the FAA prior to testing unless an existing TSO validation procedure is already published. The test would use a conformed control; a 2,000-degree Fahrenheit flame would be impinged onto the component and held in place for 15 minutes for fireproof compliance. Before removal of the flame at the termination of the test, loads should be applied to the component to show that it can still perform its intended function.

This portion of the regulations does not address engine controls. See part 23, § 23.1141(f) for requirements regarding the fire resistance testing for engine controls. Also, the reader may refer to AC 23-17A, “Systems and Equipment Guide for Certification of Part 23 Airplanes” for more information.

s. Lightning Protection of Structure, Fuel System Lightning Protection, and Systems.

(1) Regulations Reference. Sections 23.867, 23.954, and 23.1309(e).

(2) Discussion. Lightning testing is not required for those airplanes intended for operation under Visual Flight Rules (VFR) only (of any type of construction). A general engineering overview of the airplane construction features to determine that any lightning induced hazards are minimized may be all that is required, if it can be determined that sufficient conductivity is available throughout the airplane and that the design employs features that have been found to minimize the hazard to the airplane and occupants. Refer to FAA report number DOT/FAA/CT-89/22, "Aircraft Lightning Protection Handbook" for best practices. (Probability of a strike during VFR flight conditions in an airplane of this class as verified by service experience is at a level that the FAA would not require additional testing or analysis.) The Type Certificate Data Sheet (TCDS) will contain this statement: "This aircraft is not approved for Instrument Flight Rules (IFR) operation under the provisions of § 91.205(d)."

For those airplanes intended for operation under IFR a more detailed assessment will need to be made as to the vulnerability to lightning related hazards. Sections 23.867, 23.954, and 23.1309(e) of part 23 of the 14 CFR will need to be individually addressed. The depth of the verification should be commensurate with the degree of hazard. Since airplanes that employ conventional service proven construction and systems (i.e., all-aluminum airplanes with gyro flight instruments, magneto type engine ignition systems, mechanical fuel systems, etc.) have demonstrated over many millions of flight hours excellent inherent lightning protection qualities, similar designs may only need a qualitative engineering assessment that all hazards have been reasonably minimized. The Aircraft Lightning Protection Handbook, DOT/FAA/CT-89/22 may be used as a guide to make this assessment. Other designs (i.e., all composite construction or installation of electronic flight instrument displays or electronic ignition or electronic fuel systems, etc.) are generally more susceptible to lightning threats and, therefore, will need further evaluation. The methods outlined in AC 20-53A, AC 20-136, and RTCA DO-160D provide acceptable means of compliance with the requirements as applicable. AC 23.1309-1C provides an acceptable means of identifying and assessing complex critical and essential systems.

Airplanes using the foregoing means of compliance shall display the following limitation placard: Not approved or eligible in Instrument Meteorological Conditions (IMC).

See AC 23-17A "Systems and Equipment Guide for Certification of Part 23 Airplanes" for more information.

t. Fuel Tank Tests.

(1) Regulation Reference. Section 23.965.

(2) Discussion. Certain requirements as defined in § 23.965(b) and (c) would be unduly burdensome in cases where certain small aluminum or nonmetallic fuel tanks incorporate side stiffeners or beads and internally attached baffles. The FAA tests described in § 23.965(a) satisfy

the requirements if the tank has less than a 10-gallon capacity, or the tank interior has baffles (or equivalent support) at least every 15 inches in both directions.

u. Avionics Installation.

(1) Regulations Reference. Sections 23.1301, 23.1431, 23.1309(a), and 23.1311.

(2) Discussion. Section 23.1301 requires that all installed equipment perform its intended functions. For communication and navigation equipment required for IFR operations, an acceptable means of performance evaluation of these systems is provided in AC 23-8A, chapter 5.

For non-required navigation and communication equipment that could be used for flight purposes and which have not been previously approved, an acceptable means of performance evaluation of these systems is provided in AC 23-8A, chapter 5, and AC 23.1309-1C. For optional equipment that has no functions that can be utilized by the flight crew for the purpose of flight (i.e., stereo receivers, television sets, tape players, etc.), the intended function is considered to be the lack of any hazardous failure modes and the non-interference with other required equipment installed in the airplane. Evaluation of these systems should address only those failure modes or performance qualities that would directly result in hazard (fire, smoke, explosion, etc.) or indirectly affect safety by interfering with the operation of required equipment. Typically, FAA flight test pilot observation is adequate to determine any affects of interference. Non-flight related functions do not need to be evaluated. An acceptable method of evaluating adverse effects and minimizing hazards in accordance with § 23.1309(a) is provided in AC 23.1309-1C.

The requirements of § 23.1431 are self-explanatory and parallel the requirements of § 23.1309(a).

The requirements of § 23.1311 pertain to the certification of electronic display instrument system installations. An acceptable means of compliance with the specific requirements of § 23.1311 are provided by AC 23.1311-1A.

For communication and navigation equipment with previous installation approvals, an acceptable means of performance evaluation of these systems is outlined below (the intent is to verify the installation, not the ability of the already proven system):

(a) Very High Frequency (VHF) Communication Transceivers. For VFR, establish satisfactory communications with the tower while on the airport ramp and in flight at 20+/-5 Nautical Mile (NM) and the higher of 2,000 feet Above Ground Level (AGL) or Minimum Obstruction Clearance Altitude (MOCA). The flight path relative to the tower includes toward, away, 90 degrees right and 90 degrees left while in level flight at cruise power.

(b) VHF Navigation Receivers. For VFR, tune to a Visual Omni Test (VOT), or use a Visual Omni Range (VOR) checkpoint (+/-4 degrees tolerance), and fly to a VOR airborne checkpoint and check for accuracy within IFR tolerances (+/-6 degrees). The audio signal must be clearly audible.

(c) VHF Area Navigation (RNAV) Systems. VFR only: establish waypoint over known position and confirm accuracy, per the manufacturer's instructions. IFR approvals may be done in accordance with AC 20-121A, AC 20-130A, or applicable Global Positioning System (GPS) certification guidance.

(d) Automatic Direction Finder (ADF) Navigation Systems. For VFR, tune to known station; check bearing indication against known position, on the ground and at 2,000 feet AGL, or MOCA, (whichever is higher) at 20+/-5 NM, for two positions. Errors must not exceed +/-5 degrees, and the aural signal must be clearly audible.

(e) Transponders, Mode A. For VFR, ask approach control or center to confirm operation, in the traffic pattern and at 2,000 feet AGL or MOCA (whichever is higher), at 20 NM.

(f) Transponders, Mode C. For VFR, same as (v), also requesting altitude check, starting at 2,000 feet AGL, or MOCA (whichever is greater), and continuing every 2,500 feet up to 90 percent of service ceiling; starting the climb at 10 NM and ending at 80 NM from the station.

(g) Long Range Navigation Communication (LORAN-C) Systems. Use VFR only criteria of AC 20-121A.

(h) Electro Magnetic Compatibility. With all systems exercised in flight, verify by observation that no adverse effects are present in the installed equipment.

v. Equipment Systems and Installation.

(1) Regulation Reference. Section 23.1309.

(2) Discussion. For those airplanes with equipment installations where a single failure would not cause loss of safe flight capability, or if not limited to VFR operation, a failure would not result in a significant reduction in the ability of the crew to cope with adverse operating conditions, § 23.1309(a) is applicable. An example would be loss of the primary attitude indicator during an IFR flight where the pilot can maintain control of the airplane by other means such as use of a secondary attitude indicator or use of partial-panel piloting techniques. In this instance, further evaluation would not be needed other than the requirements of § 23.1309(a), which addresses adverse effects on other equipment, the minimizing of hazards on single engine airplanes, and the prevention of hazards on multiengine airplanes. The methods of compliance outlined in AC 23.1309-1C, figure 1 and paragraph 7, are acceptable for evaluating these systems.

For those airplanes with equipment installations whose failure conditions are catastrophic, the requirements of § 23.1309(b) are also applicable. The methods of compliance outlined in AC 23.1309-1C, paragraphs 9 and 10 are acceptable for evaluation of these systems.

The general considerations of § 23.1309(c) and (f) are self-explanatory and are applicable to all airplanes being evaluated. Paragraph (d) is applicable only to commuter category airplanes (this intent was inadvertently omitted with the adoption of amendment 23-41). Paragraph (e) is applicable to all installations with critical or essential functions that are also susceptible to lightning threats and radio frequency energy threats (other than High Intensity Radiated Fields (HIRF). This is discussed in paragraph "4s" of this AC and in AC 23.1309-1C, paragraph 11.

Those systems employing software in their design will need further evaluation. AC 23.1309-1C, paragraph 12 discusses this. AC 20-115B, and RTCA/DO-178B, is an acceptable means of assessing these systems.

w. Airplane Flight Manual.

(1) Regulations Reference. Sections 23.1581, 23.1585, and 23.1587.

(2) Discussion. For small airplanes, compliance is met by computing performance at two temperatures--standard day, and standard day +30 degrees Centigrade, and at least three altitudes for takeoff and landing distance and climb data expanded to a minimum of 10,000 feet altitude.

A presentation (the use of tables/charts rather than graphs) similar to that found in figure 13 is acceptable.

TAKE-OFF DISTANCE-FLAPS RETRACTED-HARD SURFACE RUNWAY @ 1600 LBS WT. & 68 KNOT CLIMB SPEED

Wind	Sea Level (59F)		2500 FT (50F)		5000 FT (40F)		7500 FT (32F)	
	DISTANCE	50 FT ALT.	DISTANCE	50 FT ALT.	DISTANCE	50 FT. ALT.	DISTANCE	50 FT ALT.
0	735	1385	910	1660	1115	1985	1360	2440
10	500	1035	800	1250	780	1530	970	1875
20	305	730	395	890	505	1090	840	1375

Notes
1. Increase the distances 10% for each 35F increase in temperature above standard for the particular altitude
2. For operation on dry, grass runway, increase distances (both "DISTANCE" and "Total to clear 50FT ALT".) by 7% of the "50FT ALT." figure.

MAXIMUM RATE-OF-CLIMB DATA @ 1600 LBS

SEA LEVEL (59F)			5000 FT (41F)			10,000 FT (23F)		
IAS	R.O.C.	Fuel Used Gal.	IAS	R.O.C.	Fuel Used S.L. GAL.	IAS	R.O.C.	Fuel Used S.L. GAL.
74	670	0.6	71	440	1.6	67	220	3

Notes
1. Flaps retracted, full throttle, mixture leaned to smooth operation above 5000 FT.
2. Fuel used includes warm-up and take-off allowances
3. For hot weather, decrease rate of climb 15FT/min for each 10F above standard day temperature for particular altitude

LANDING DISTANCE--FLAPS 40 DEGREES, POWER OFF HARD SURFACE RUNWAY--ZERO WIND @ 1600 LBS. & 60 KNOTS

SEA LEVEL (59F)		5000 FT (50F)		5000 FT (41F)		7500 FT (32F)	
DISTANCE	50FT ALT.	DISTANCE	50FT ALT.	DISTANCE	50FT ALT.	DISTANCE	50FT ALT.
445	1075	470	1135	495	1195	520	1255

Notes
1. Decrease the distances shown by 10% for each 4 knots increase in headwind.
2. Increase the distance by 10% for each 60F temperature increase above standard.
3. For operation on a dry, grassy runway, increase distances ("Both "DISTANCE" and Total to clear 50FT ALT.") by 20% of the " 50FT ALT." figure.

Figure 13 - PERFORMANCE CONTENT AND FORMAT

DRAFT

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